
ABB’s Sensi+™ is a compact natural gas contaminants analyzer based on a unique tunable diode laser (TDL) technology known as Off-Axis Integrated Cavity Output Spectroscopy (OA-ICOS). The technology accurately, reliably and simultaneously measures corrosive substances such as hydrogen sulfide, carbon dioxide and water in real time in complex and time-varying natural gas streams.

Natural gas stream composition varies from site to site based on the type of well at the source and the stage of processing and distribution where the sample is probed. While one measurement point is unlikely to see the full range of possible natural gas stream compositions, there will be short-term variations from the well or process and long-term variations as the reservoir ages. Additionally, gas standards that are used to validate instruments are not readily available in custom natural gas blends, they’re typically only available in methane. For accurate, reliable measurement of gas contaminants, it is critical that the instrument is sensitive only to the contaminant itself and is not impacted by any variance in the gas stream composition.

This variation, known as cross-interference, is a common challenge for most analytical instruments, including those based on TDL technology. TDL-based sensors measure the absorption of laser light by analyte gases to determine the amount of contaminant in the gas stream. However, the hydrocarbons in natural gas absorb the light along with the contaminant gas, even after selecting optimal wavelengths to specifically target the contaminant gas. Some techniques rely on differential absorption spectroscopy where a scrubber is used to periodically remove the contaminant gas from the stream and measure a background absorption spectrum that can be subtracted from subsequent measurements to isolate the contaminant. This method requires a consumable scrubber and cannot track changes in the gas stream between background reference measurements.
On the other hand, Sensi+ is extremely sensitive to even small changes in the absorption spectrum due to the long effective pathlength inherent to OA-ICOS™. Recent advances in ABB’s spectroscopic analysis algorithms make it possible to differentiate the contaminant gas absorption from the background natural gas absorption without the need for chemical gas scrubbers. In the example spectra shown in figures 1 and 2, H₂S, H₂O, and CO₂ have distinct absorption peaks while the hydrocarbons have a complex absorption profile. Methane is highly structured, but that diminishes for ethane as the molecule gets larger. Propane and larger molecules are purely broadband absorbers without any structure.

Sensi+ analyzers have been tested over a wide range of natural gas mixtures using a custom multiple gas blender based on mass flow controllers. In the example shown in figure 3, methane and carbon dioxide were mixed at different ratios while hydrogen sulfide was held constant. This was repeated for streams with ethane and larger hydrocarbons. Two Sensi+ analyzers were configured in parallel to measure all three gas contaminants in the varying mixture from the gas blender. Similar validation experiments were performed while carbon dioxide and water were held constant. For water, the measurements were compared with a chilled mirror hygrometer measuring the same gas stream in parallel to eliminate any errors from adsorption in the gas blender or uncertainties in the raw gas cylinders. Figures 4, 5 and 6 show the combined results for H₂S, CO₂ and H₂O respectively as the background varies over a wide range of possible natural gas stream compositions.

Interference uncertainty, as defined by IEC 61207, is less than 2% of reading for H₂S and CO₂, and less than 3% of reading for H₂O across the natural gas and biogas stream compositions.
03 Measurements of H$_2$S and CO$_2$ showing H$_2$S sensitivity to cross interference from CO$_2$ while CO$_2$ varied in a balance of CH$_4$.

04 H$_2$S measurements of 20 ppmv while the amount of CO$_2$, C$_2$H$_6$ or C$_3^+$ mixed with CH$_4$ varied.
While cross-interference remains a familiar challenge for many analytical instruments, the sensitivity of OA-ICOS and recent advancements in spectroscopic analysis algorithms have enabled the discrimination of contaminant gas absorption from the inherent absorption of background natural gas. This achievement eliminates the necessity for chemical gas scrubbers or custom analyzers for narrowly defined applications. With Sensi+, confidently measure contaminants in natural gas regardless of the source gas, processing and distribution stage, or any other cause of gas stream composition variation.